

4.0 Exposure Factors

This section describes the development of the exposure factors used in IWAIR. These factors are used in the risk equations documented in Section 6. All data in this section are from the *Exposure Factors Handbook* (U.S. EPA, 1997a; hereafter, the EFH). These exposure factors are used only for carcinogenic chemicals (see box below for carcinogens included in IWAIR; the user may add additional carcinogens). For noncarcinogens, the HQ is a ratio of air concentration to the health benchmark (an RfC), and no exposure factors are used.

All exposure factors were developed for the following subpopulations:

- Children aged <1 year
- Children aged 1–5 years
- Children aged 6–11 years
- Children aged 12–18 years
- Adult residents (aged 19 and older)
- Workers.

The age ranges for children were selected for consistency with the data on inhalation rate in the EFH. Most exposure factors were selected to represent typical or central tendency values, not high-end values.

Carcinogens Included in IWAIR

Acetaldehyde	Dichloropropylene, cis-1,3-	Methylene chloride
Acrylamide	Dichloropropylene, trans-1,3-	Nitropropane, 2-
Acrylonitrile	Dimethylbenz[<i>a</i>]anthracene, 7,12-	N-Nitrosodiethylamine
Allyl chloride	Dinitrotoluene, 2,4-	N-Nitrosodi- <i>n</i> -butylamine
Aniline	Dioxane, 1,4-	N-Nitrosopyrrolidine
Benzene	Diphenylhydrazine, 1,2-	Propylene oxide
Benzidine	Epichlorohydrin	TCDD, 2,3,7,8-
Benzo(<i>a</i>)pyrene	Ethylbenzene	Tetrachloroethane, 1,1,1,2-
Bromodichloromethane	Ethylene dibromide	Tetrachloroethane, 1,1,2,2-
Butadiene, 1,3-	Ethylene oxide	Tetrachloroethylene
Carbon tetrachloride	Formaldehyde	Toluidine, o-
Chlorodibromomethane	Hexachloro-1,3-butadiene	Tribromomethane
Dibromo-3-chloropropane, 1,2-	Hexachlorobenzene	Trichloroethane, 1,1,2-
Dichlorobenzene, p-	Hexachloroethane	Trichloroethylene
Dichloroethane, 1,2-	Methyl chloride (chloromethane)	Vinyl chloride
Dichloroethylene, 1,1-	Methylcholanthrene, 3-	

Table 4-1 summarizes the exposure factors used in IWAIR. Sections 4.1 through 4.4 describe how the values for inhalation rate, body weight, exposure duration, and exposure frequency, respectively, were determined.

Table 4-1. Summary of Exposure Factors Used in IWAIR

Receptor	Inhalation Rate (m³/d)	Body Weight (kg)	Exposure Duration (yr)	Exposure Frequency (d/yr)
Child <1	4.5	9.1	1	350
Child 1–5	7.55	15.4	5	350
Child 6–11	11.75	30.8	6	350
Child 12–18	14.0	57.2	7	350
Adult Resident	13.3	69.1	11	350
Worker	10.4	71.8	7.2	250

4.1 Inhalation Rate

To assess chronic exposures, an average daily inhalation rate is needed. Such a rate is based on inhalation values for a variety of activities averaged together.

Table 4-2 summarizes the inhalation rates for long-term exposure recommended in the EFH. The values for adult females (11.3 m³/d) and adult males (15.2 m³/d) were averaged and used in IWAIR. For children, the values for males and females were first averaged for each age group if they were not presented as combined male/female. These combined male/female rates for each age group were averaged to form the age groups used in IWAIR. For example, the combined values for ages 1–2 and 3–5 were averaged to obtain a value for ages 1–5.

Table 4-2. Recommended Inhalation Rates for Residents

Age (yr)	Inhalation Rate (m ³ /d)		
	Males	Females	Males and Females
<1	NA	NA	4.5
1–2	NA	NA	6.8
3–5	NA	NA	8.3
6–8	NA	NA	10
9–11	14	13	NA
12–14	15	12	NA
15–18	17	12	NA
Adults (19–65+)	15.2	11.3	NA

NA = Not available.

Source: U.S. EPA, 1997a, Table 5-23.

Table 4-3 summarizes the values for inhalation rate for workers presented in the EFH. The recommended hourly average of 1.3 m³/h was used in IWAIR. To convert this to a daily value, an 8 h workday was assumed, yielding a daily inhalation rate for workers of 10.4 m³/d. This rate is lower than the adult resident average because it only accounts for 8 h/d instead of 24 h/d.

Table 4-3. Recommended Inhalation Rates for Workers

Activity Type	Mean (m ³ /h)	Upper Percentile (m ³ /h)
Slow activities	1.1	NA
Moderate activities	1.5	NA
Heavy activities	2.3	NA
Hourly average	1.3	3.5

NA = Not available.

Source: U.S. EPA, 1997a, Table 5-23.

4.2 Body Weight

Body weights were needed that were consistent with the inhalation rates used. Therefore, body weights were needed for children aged <1, 1–5, 6–11, and 12–18 years; adult residents aged 19–29 years; and workers of all ages.

The EFH presents summary data on body weight for adults in EFH Table 7-2. The data for males and females combined are summarized here in Table 4-4. Because an adult resident aged 19–29 was desired, the weighted average of the values for adults aged 18–24 and 25–34 was used, weighting each by the number of years in that age range (six in the 18–24 range and five in the 25–34 range).

Table 4-4. Body Weights for Adults, Males and Females Combined, by Age

Age (yr)	Body Weight (kg)
18–24	67.2
25–34	71.5
35–44	74.0
45–54	74.5
55–65	73.4
65–74	70.7
All (18–74)	71.8

Source: U.S. EPA (1997a), Table 7-2.

For children, the EFH contains mean body weights for 1-year age intervals (e.g., 1 year, 2 years). These values, summarized in Table 4-5 were averaged across the age ranges used in IWAIR.

**Table 4-5. Body Weights for Male and Female Children
Combined, Aged 6 Months to 18 Years**

Age (yr)	Mean (kg)	Age (yr)	Mean (kg)
6–11 months	9.1	10	36.3
1	11.3	11	41.1
2	13.3	12	45.3
3	15.3	13	50.4
4	17.4	14	56.0
5	19.7	15	58.1
6	22.6	16	62.6
7	24.9	17	63.2
8	28.1	18	65.1
9	31.5		

Source: U.S. EPA (1997a), Table 7-3.

4.3 Exposure Duration

For residents, exposure duration was based on data on population mobility reported in the EFH. An overall exposure duration of 30 years, which represents the 75th to 90th percentile for all ages and genders (EFH, Table 15-167), was selected as a high-end value for residents. The 30-year exposure duration was then allocated to the various age ranges modeled, based on the number of years in each age bracket.

For workers, the typical default exposure values used in the past were an 8 h shift, 250 d/yr, for 40 years. The EFH presents data on occupational mobility that are in stark contrast to the assumed value of 40 years at a single place of employment. As presented in the EFH, the median occupational tenure of the working population (109.1 million people) aged 16 years and older in January 1987 was 6.6 years. This value includes full- and part-time workers. The worker modeled in IWAIR is assumed to be a full-time worker. Therefore, a value of 7.2 years, from EFH Table 15-160 and reflecting the median for full-time male and female workers of all ages, was used.

For most unit types, exposure is expected to end when the unit is closed. If this is the case, then exposure duration should not exceed the specified operating life of the unit. In IWAIR, the surface impoundment, landfill, and waste pile are assumed to conform to this expectation. Thus, for those unit types, if the user specifies an operating life of the unit less than

the above exposure duration for the selected receptor type, then the operating life is used instead. Land application units are an exception to this assumption. Exposure to constituents applied to land application units is expected to continue after closure. Therefore, in IWAIR, the exposure duration for land application units is not capped using the operating life specified, but is always 30 years for residents and 7.2 years for workers.

4.4 Exposure Frequency

Exposure frequency is the number of days per year that a receptor is exposed. A value of 350 d/yr was used for residents, and a value of 250 d/yr was used for workers. These are based, respectively, on 7 d/wk and 5 d/wk for 50 wk/yr and account for the receptor being elsewhere on vacation for 2 wk/yr.